IN SEARCH OF MECHANISMS. CONDUCTING A CRITICAL REALIST DATA ANALYSIS

Completed Research Paper

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Abstract

Critical realism has emerged as an alternative to positivist and interpretive research during the past decade. Yet, the number of empirical studies based on this perspective has so far been limited. This indicates a need for a more explicit method for critical realist data analysis. To address this, we extend former research on critical realist methodology by presenting a framework for identifying and understanding causal structures in critical realist studies, termed mechanisms. The framework consists of steps involved in identifying structural components of a mechanism, how these components interact to produce to an outcome, and contextual influences on this outcome. We illustrate the application of the framework through an example of the identification of IS innovation mechanisms in a case study in the airline industry. Overall, we argue that the mechanism approach can improve empirical studies in the IS field, by providing ontological depth, creative thinking and more precise explanations.

Keywords: Research methods, Critical realism, Mechanisms, Case study, Data Analysis

Introduction

Critical realism has gained increasing interest during the last decade as an alternative to positivist and interpretive IS research (Dobson 2002; Mingers 2004; Smith 2006, 2010; Volkoff et al. 2007; Lyytinen and Newman 2008; Bygstad 2010, Strong and Volkoff 2010). Critical realism combines a realist ontology with an interpretive epistemology (Bhaskar 1998b; Archer 1995); although a real world exists, our knowledge of it is socially constructed and fallible. Proponents of the critical realism perspective argue that the non-deterministic view on causality developed in this research approach may serve to resolve the inconsistency between implicit ontological assumptions and research practice (Mingers 2004; Smith 2006), where both positivist and interpretivist researchers "arguably rely on a realist ontology with a non-empirical, non-deterministic notion of causality that conflicts with their philosophical stance" (Smith 2006, p. 198). This inconsistency between the ontological and epistemological level is also discussed by Burrell and Morgan in the term of *ontological oscillation* (Burrell and Morgan 1979). We agree with Smith (2006) that this is a barrier for developing useful theories in IS.

Causality is a contentious issue in philosophy, which is addressed in depth in the critical realist literature (Bhaskar 1998a,b; Sayer 1992). We relate to this discussion, but the ambition of this paper is more limited; we investigate the methodological aspects of causality when conducting an empirical data analysis based on a critical realist perspective. In this perspective, causality is expressed in the term *mechanism*, simply defined as a causal structure that explains a phenomenon (Bhaskar 1998b). For

example, in the economics field we investigate the *market mechanism*, which explains how the price of a good is caused by demand and supply. In sociology researchers have shown that a mechanism, called the *self-fulfilling prophecy,* can explain human behavior in such situations as a "run" on a bank: the belief that the bank may go bankrupt makes customers run for their money, and eventually – although the bank may have been relatively solid - cause bankruptcy (Hedstrom and Swedberg 1998). In the IS field a well-known mechanism is Grindley's (1996) *standards reinforcement mechanism*; a large installed base of users of a technical standard will attract complimentary products. This gives the standard more credibility, which will increase the usefulness of the standards and attract more users, which increases the installed base, and so on.

While critical realism has attracted much interest as a philosophy and a social theory, the empirical work based on this approach has been limited, both in IS research and in social science research in more general (Dobson et al. 2007). A review on the occurrences of critical realism in social science publications from 1979-2006 found that less than 5 % of the published papers included fieldwork, either qualitative or quantitative (de Vaujany 2008). We argue that the limited amount of empirical research based on the critical realism perspective can be partly explained by the lack of a more explicit methodology for data analysis, to aid the researcher in the search for generative mechanisms. While there is a sound methodological basis in critical realism research at a general level, there are many practical questions facing the IS researcher that embarks on a quest for generative mechanisms. What is really a mechanism? If it is not observable, how can it be identified? At which level should it be described? How do we evaluate a proposed mechanism?

This aim of this article is to contribute to the knowledge on critical realist methodology, by discussing a data analysis framework for identifying mechanisms. In this, we build on and extend former realist methodological contributions (e.g. Sayer 1992; Danermark et al. 2002; Sayer 2002; DeLanda 2006; Smith 2010; Easton 2010;). The framework consists of steps involved in identifying structural components of a mechanism, how these components interact to produce an outcome, and contextual influences on this outcome. We illustrate the application of the framework through a relatively detailed example of the identification of IS innovation mechanisms in a case study in the airline industry.

We start out by reviewing literature on critical realism and in particular the definition of mechanisms. Then we present and discuss the key critical realist ideas of data analysis, and synthesize these contributions into a stepwise framework for the identification and evaluation of mechanisms. We then use the framework to conduct a data analysis of a longitudinal case study, and assess the opportunities and limitations of the approach. Finally, we conclude with some implications for further research.

Critical Realism and Methodology

Critical realism is a philosophy attributed to the British philosopher Roy Bhaskar, but also a social theory and - with some limitations - a methodology. In this section we briefly comment on some key concepts in critical realism; then we proceed to discuss it as a research methodology.

Theory

The basic assumption of critical realism is the existence of a real world independent of our knowledge of it (Bhaskar 1998b). Reality is conceived as being stratified in three domains; the real, the actual and the empirical. The *real* domain consists of structures of objects, both physical and social, with capacities for behavior called mechanisms. These mechanisms may (or may not) trigger events in the domain of the *actual*. In the third layer these events may (or may not) be observed, in the *empirical* domain. Thus, structures are not deterministic; they enable and constrain events (Archer 1995; Sayer 2004).

Critical realism combines a realist ontology with an interpretive epistemology (Archer et al. 1998). This does not imply a judgemental relativism; since a real world does exist critical realism holds that some theories *approximate* reality better than others, and that there are rational ways to assess knowledge claims. The relationship between agency and structure in critical realism was developed in Bhaskar's *transformational model of social action* and later in Archer's (1995) *morphogenetic model*. They share

with Giddens' structuration theory the assumption that action and structure are mutually constituted. In the critical realist view, however, social structure exists independently of *current* human activity. This implies that although structure exists only through human activity, it is not reducible to such activity. This resonates intuitively with IS research, which addresses not only user experiences, but also deals with large, durable technical systems and socio-technical structures (Kallinikos 2004). Structure enables and constrains action. Human action reproduces or transforms structure, although this is not usually the intention of the activity.

Methodology

It follows from these assumptions that critical realism does not aim to uncover general laws, but to understand and explain the underlying mechanisms. According to Bhaskar, the objects and structures of the real give rise to causal powers, called *generative mechanisms*, which causes the events that we may observe (Bhaskar 1998b). The basic objects and mechanisms are usually not observable. For example, while we may observe buyers and sellers agree on prices and volumes, the underlying market mechanism is unobservable.

The layered ontology (illustrated in figure 1) is the key to the critical realist methodology. Contrary to positivist research, the aim of critical realism in not to investigate regularities at the level of events, but rather to uncover and describe the mechanisms that produced these events. Mechanisms are associated to the *nature* of the objects of the real, i.e. they are relatively stable structures which are often triggered by the interplay of objects.

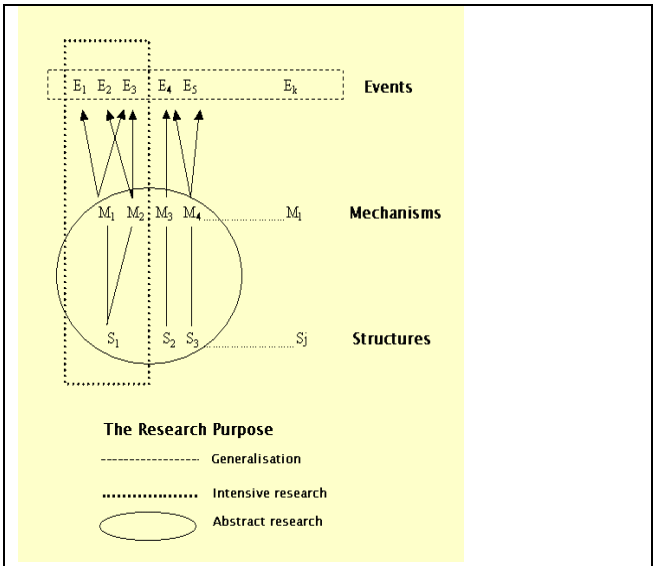

Figure 1. The layered ontology of critical realism, and research strategies (Sayer, 1992).

Thus, instead of aiming to generalize at the level of events, critical realism methodology rests on *abstract research*, which aims at a theoretical description of mechanisms and structures, in order to hypothesize how the observed events can be explained. A typical critical realist research design would be an intensive study, with a limited number of cases, where the researcher systematically analyzes the interplay between the layers, as illustrated in figure 1.

The methodological question is; how do we identify mechanisms, since they are not observable? As Bhaskar puts it, "theoretical explanation proceeds by description of significant features, retroduction to

possible causes, elimination of alternatives and identification of the generative mechanism or causal structure at work" (Bhaskar 1998a: xvii).

This technique is called *retroduction*; we take an empirical observation and hypothesize a mechanism that might explain that particular outcome (Danermark 2002; Sayer 2004). For example, if we observe that some IS solutions are more easily diffused than others we may ask which mechanism that might explain the phenomenon.

Mechanisms

In the social sciences the search for mechanisms often builds on the work of Robert Merton, who argued for the development of middle range theory, focusing on social mechanisms (Merton 1967). More recently, Hedstrøm and Swedberg's work on social mechanisms has triggered a new and strong interest in the phenomenon. They argued forcefully that "the essential aim of sociological theorizing should be to develop fine-grained middle-range theories that clearly explicate the social mechanisms that produce observed relationships between explanans and explanandum" (Hedstrom and Swedberg 1996, p.281). The point is that a correlation between two observed phenomena is not sufficient as an explanation. For example, while many people are scared of electromagnetic radiation (and there has certainly been shown some correlation between radiation from mobile phones and medical problems), medical researchers are reluctant to accept this evidence, because - so far - there is no documented biological mechanism that explains *how* electromagnetic radiation (of this limited magnitude) constitutes a medical hazard.

Mechanisms are at the center of a critical realist methodology. At a general level a mechanism is a causal structure that can trigger events (Bhaskar 1998b). However, at a more detailed methodological level the understanding of mechanisms is more challenging. Bunge defined a mechanism as "one of the processes in a concrete system that makes it what it is - for example, metabolism in cells, interneuronal connections in brains, work in factories and offices, research in laboratories, and litigation in courts of law" (Bunge 2004, p.182).

The term has caused much debate and critique, since it indicates a linear causality; that it produces the same outcome every time it is triggered. This is rejected by critical realists, who emphasize that the outcome of a mechanism is contextual, i.e. dependent on other mechanisms. Thus, a mechanism may produce an outcome in one context, and another in a different context. This *contingent causality* (Smith 2010) is inherent in all open systems, and warns us that we can mainly use mechanisms to explain phenomena; not to predict them. Although the term may be unfortunate in its mechanical connotations, the main reason to stick with it is that it denotes causality in a direct and material sense; mechanisms make things happen in the material world.

All mechanisms are "stuff-dependent and system-specific" (Bunge 2004, p.195). Because of their contextual nature, the basic structure of mechanisms is often described in a *context-mechanism-outcome* pattern (Pawson and Tilley 1997). For example, in an IS context we could describe a well-known mechanism this way: user participation in IS development may lead to a higher degree of user acceptance of an IS solution. The necessary context might be that the users and developers are willing to share knowledge, and that the technical environment is sufficiently flexible to accommodate changes.

Identifying Mechanisms

Beyond the general approach of retroduction there is currently no shared body of knowledge on the more specific identification of mechanisms, and one might ask whether retroduction or abduction qualify as a *method*. Bunge warns against the possibility of a method or technique for uncovering mechanisms. "There is no method, let alone a logic, for conjecturing mechanisms. True, Peirce wrote about the "method of abduction," but 'abduction' is synonymous with 'conjecturing', and this—as Peirce himself warned—is an art, not a technique. One reason is that, typically, mechanisms are unobservable, and therefore their description is bound to contain concepts that do not occur in empirical data" (Bunge 2004, p.201).

The point is relevant, but it should not be overstated. As noted by Popper, the engine of scientific enquiry is conjectures (Popper 2003), and many scientific concepts do not "occur" in our empirical data. The critical realist position is that there are indeed methodological ways to formulate conjectures, building on

systematic knowledge. The point is that, in a layered ontology, we are looking for regularities at the level of objects and structures, not in the empirical data. These mechanisms are associated with the *nature* of the object of study, not with the attributes of events.

While there is no established methodology for the identification of mechanisms, there are some key contributions that together may provide the basis for a consistent methodology. We take these to be Sayer's work on critical realism general methodology (Sayer 1992; Sayer 2000) and Danermark et al.'s work on realist explanations in the social sciences. Sayer is a sociologist who has written extensively on critical realism as a social theory and research method, mainly at a general level without specific methodological details. Danermark et al. (2002) have contributed a more detailed description on realist explanations, particularly in the field of social welfare. Unfortunately, none of them have much to say about technology. Therefore we will also draw on the contributions of DeLanda (2004), Smith (2010) and Easton (2010), relating to IS research by paying particular attention to the socio-technical nature of modern organizations.

A Stepwise Framework for Critical Realist Data Analysis

According to Sayer retroduction is a "...mode of inference in which events are explained by postulating (and identifying) mechanisms which are capable of producing them" (Sayer, 1992, p.107). The concept of *emergence* is central to the workings of mechanisms; it is often a combination of objects that will trigger a mechanism, and produce an outcome that is dependent on, but not reducible to the objects. For example, the interplay of humans and technology may trigger a number of mechanisms relevant for the IS field. Whether the mechanism will be triggered, and which result it will produce, is not predetermined, but will depend on other active mechanisms. However, it will have a *tendency* to produce certain outcomes. For example, in IS development user participation usually increases the probability of user acceptance – but not always.

Thus, first we need to identify the structural components of the mechanism. Then we must understand how these components interact in order to produce the emergent outcome. Then we need to identify and analyze the outcome tendency. And finally, we need to identify the context (i.e. other mechanisms) that influence on the outcome.

We suggest the following steps and principles for conducting a critical realist data analysis. We will briefly illustrate each step with examples from IS research.

1. Description of events
2. Identification of key components
3. Theoretical re-description (abduction)
4. Retroduction: Identification of candidate mechanisms
5. Analysis of selected mechanisms and outcomes
6. Validation of explanatory power

Step 1: Description of events

In a critical realist context events are clusters of observations, which may have been made by the researcher or by the researcher's informants (Sayer 1992). Typical events in an IS case are, for instance, the decision to buy an ERP system, the technical integration of the ERP system with other systems (which may be problematic), and the training of users (which may be met with resistance).

Step 2: Identification of key components

The key components are the real objects of the case, for example persons, organizations and systems. They constitute structures, i.e. networks of objects, with causal powers. Entities may emerge from data, in a grounded way (see Volkoff et al., 2007), or they may be embedded in a theoretical framework (Danermark et al. 2002). For example, Easton analyzes a CRM case, and identifies four entities based on

an economic exchange model: the company, the CRM vendor, the exchange relationship and a government knowledge transfer program (Easton 2010).

Step 3: Theoretical re-description (abduction)

To be able to work with retroduction we need to abstract the case, exploring different theoretical perspectives and explanations (Danermark et al. 2002). A case is a *case of something*, which transcends the actual events. Theoretical re-description could be based on social theory (such as Giddens' structuration theory) or more limited middle range theory. According to Danermark et al. the researcher should identify relevant theories, and compare and integrate them when possible, in order to increase theoretical sensitivity and understand the events in more depth.

For example, Smith researched the relationship between e-government and citizens' trust in government institutions. Discussing theories of trust at three different levels (starting with sociology and psychology) enabled him to reframe and generalize the case (Smith 2010).

Step 4: Retroduction: Identification of candidate mechanisms

This step is the most crucial, and we will detail it into two sub-steps.

Sub-step 4.1: The interplay of objects. In the IS field this interplay is often between social and technical objects (identified in step 2), which allows for the identification of socio-technical mechanisms. Objects have internal attributes (such as structure) and external attributes (such as interfaces, or modes of communication), which allows for interplay with other objects, and we should focus on these in order to identify relations of exteriority: for example, we should look for *how* social entities interact with technical entities, to produce the observed outcomes. As an example, Lyytinen and Newman (2008) used the four elements from Leavitt's diamond (people, technology, organization and tasks) to describe how the interplay between them constituted the mechanisms of socio-technical change.

Sub-step 4.2: Looking for micro-macro mechanisms. According to DeLanda (2006, p.34), we should look for two types of mechanisms:

- The *micro-macro mechanisms*, which explain the emergent behavior, i.e. how different components interact in order to produce an outcome at a macro level.
- The *macro-micro mechanisms*, which explain how the whole enables and constrains the various parts.

The notions of macro and micro should not be understood absolutely, such as human individuals at a micro level and society at a macro level. Rather, DeLanda uses these terms in a relativistic way; an object is *macro* related to sub-level components, but *micro* related to higher levels. A particularly interesting kind of mechanism in IS research is the self-reinforcing mechanism, which combines both DeLanda's types.

Step 5: Analysis of mechanisms and outcomes

In an open system there are a number of mechanisms. When we have found a new mechanism, we can identify others by asking how the context (i.e. other mechanisms) influences on the triggering of the mechanism (Sayer 1992).

A more detailed analysis of the selected mechanism(s) includes using the Context-Mechanism-Outcome form (Pawson and Tilley 1997). The outcome of mechanisms could be analyzed with forward chaining (in order to understand intentions) and backwards chaining (to understand results) (Pettigrew 1985). Context includes other active mechanisms; at a deeper level there is a continuous interaction between causal powers which will change contingencies (Yeung, 1997). For instance, if we studied user participation in IS development, and found that in some cases it did *not* result in user acceptance, we should look for other mechanisms that are influencing on the outcome, and describe the necessary context (for successful user participation) accordingly.

Step 6: Validation of explanatory power

In any open system there are a number of mechanisms, and the aim of analysis is not to find as many as possible; on the contrary, the aim is to identify a key mechanism. This would be the mechanism with the strongest explanatory power related to the empirical evidence, i.e. the causal structure that explains best the events observed (Sayer 1992). A proposed mechanism should be treated as a candidate explanation, and the data collection and analysis should be repeated until closure is reached. In addition, other techniques for validation could be used, for example informants' feedback (Bygstad and Munkvold 2011).

The results from points 1-6 do not complete the research process, but constitute the evidence for a further discussion on (i) the similarities with other mechanisms and (ii) the theoretical and practical implications of the analysis conducted. According to Easton (2010), "generalization to theory via case research carried out under critical realist conventions occurs by virtue of clarifying the theoretical nature of the entities involved, the ways in which they act and the nature and variety of mechanisms through which they exert their powers or acted upon by other entities" (p. 128). We also refer to his study for discussion on critical realist case method leading up to the data analysis stage.

Summing-up these points, we would suggest that an objective for a critical realist-inspired IS researcher could be to identify *socio-technical mechanisms*, i.e. mechanisms that are triggered by the interaction of social and technological objects. Further, since we often are dealing with large socio-technical structures, such as information infrastructures, we should look for socio-technical mechanisms that are "self-feeding" or self-reinforcing. Such mechanisms are for example growth mechanisms; that certain forms of technology adoption leads to more use, and so on. An illustrating example was described by Ciborra and Failla who investigated a CRM implementation failure (Ciborra and Failla 2000). Analyzing the reasons for the failure they concluded that there was nothing wrong with neither the organization nor the CRM software, but that "CRM seems to have no built in mechanisms by which it acquires its own momentum and the diffusion becomes a self-feeding process". This implied that although the implementation process was well conducted, there is an underlying problem with the CRM concept that makes implementation an uphill struggle. Thus, the knowledge of mechanisms is not only theoretically interesting, but also has practical implications.

Case Example: The Search for Mechanisms in IS Innovation Research

Our example is an IS innovation study, where we tried to understand the complex interactions that led to a successful innovation; the interplay of human, social and technical elements. We do not pretend that this is a perfect or even strong example of how a critical realist analysis can be conducted, but we think it is illustrative for the steps of the proposed framework.

As defined by Schumpeter, an innovation is a new combination of known products, processes, markets or organization which is commercially successful (Schumpeter 1934). A key question in innovation research is; what explains a successful innovation, in contrast to a failed one (Tidd and Hull 2003)? Current IS research has been investigating this issue in the context of Internet based services, where researchers have found some extremely successful innovations, such as Amazon and Google (Cai et al. 2008; Iyer and Davenport 2008), many relatively successful ones, and a large number of failures. What explains the outcome of an innovation initiative in this area?

We investigated this question in a longitudinal study in an airline company, Norwegian Corp. The longitudinal approach allowed us to conduct a process analysis (Langley 1999) on how events unfold and relate over time. But it also allowed us to go deeper, in order to investigate the mechanisms related to innovation in such infrastructures.

The Case

Norwegian Corp is an international airline carrier based in Norway. Its strong growth started in 2002, when it established a national network, helped by the government deregulation of the airline industry. Today Norwegian operates a total of 238 routes to 95 destinations in Europe and the Middle East, and carried 13 million passengers in 2010. The company has 2500 employees and revenues in 2010 were $ 1.5

bn. The company has pioneered the Scandinavian low-price airline market, and has been quite innovative, as described below.

The case was studied by the first author over a period of two years, using a critical realist approach. It is documented in more detail in (Bygstad 2010). The focus of the study was to understand the relationship between IT capabilities and business innovation. The initial assumption was that there indeed was a relationship, but earlier studies had not described it in detail. In this paper we describe the results of a post hoc analysis, using the proposed six step framework. It should be emphasized that the analysis process was much less sequential than described here; in practice the researcher went back and forth. The researcher also went back to the informants several times and asked for more details during the research process. The steps do, however, give a reasonably precise picture of the analytical process.

Step 1: Description of events

The identification of events was done partly by the informants, and partly by the researcher. Some events were identified by their direct business importance, while others were emerging from a number of observations. For example, the 2003 event of an introduction of a service oriented architecture (SOA) was identified after several rounds of interviews, where the researcher tried to understand the interplay of technical solutions and the innovation of new services.

Some important events were:

2003: Implementing a service oriented architecture (SOA)

As a new entrant into the very competitive airline market, Norwegian started in 2002 with a very basic IT solution. As the company expanded quickly, the need for an IT architecture was acknowledged, and a CIO and two IT architects were hired from one of the competitors. They had rather clear ideas on what to do and started in 2003 to construct a new architecture. The aim was to develop a service oriented architecture by using a simple *enterprise service bus*, enabling easy communication across different technologies and reuse of components. The solution was developed in 2004, and gradually expanded over the following years.

2004: Bypassing travel agencies, by Internet sales and print-out tickets with barcode identification

After establishing the enterprise SOA in 2003, the solution was set into production in 2004. The main challenge at the time was how to make customers book on the Internet, and not at travel agents, whose services were quite expensive for a low-cost airline. This was achieved through an Internet portal and laser printed tickets.

2005: Introducing the low-price calendar

A major obstacle for low-price passengers at the time was how to find the cheap tickets, which used to be hidden inside a complex pricing structure. Capitalizing on their new architecture Norwegian solved this problem in 2005 when the *low-price calendar* was introduced, which showed the cheapest flights to any chosen destination. The low-price calendar was an outstanding success, increasing the number of bookings substantially. It was later copied by many other airlines.

2006: Dialogue with 90% of customers is electronic

This dialogue included email and web marketing, on-line sales, booking and check-in.

2007: Bank Norwegian was launched

In 2007 the company decided to enter the banking market with Bank Norwegian. The aim was to capitalize on the 2-3 million visitors on the airline web site. The Director of Business Development commented: “We had established a very flexible IT architecture, and we realized at the time that it would be possible to innovate new services on this. First we were just brainstorming rather freely; how could a combination of brand and technology generate new business?” The establishment of the bank was done during 6 months, serving 50.000 customers in 2008.

2008-2011: Establishing Call Norwegian mobile solution

The aim of the mobile portal was to allow for easy airline booking, and to offer mobile broadband on the airport and (later) during flight. The mobile solution was extended in 2009, when the possibility of having a bar code ticket on the mobile phone was introduced. In 2010 Call Norwegian launched GSM and mobile broadband services. In February 2011 Norwegian was the first European airline to offer broadband services on board.

Step 2: Identification of key components

The key objects of the study were identified this way, starting with the events. Which objects were these events associated to? The Norwegian internal organization was analyzed in structural, process and cultural dimensions. Key persons were identified. The IT systems were mapped, and the IT architecture was documented, as shown in figure 2 below. The link to external systems, such as the European Amadeus booking system was documented, and important partners were identified.

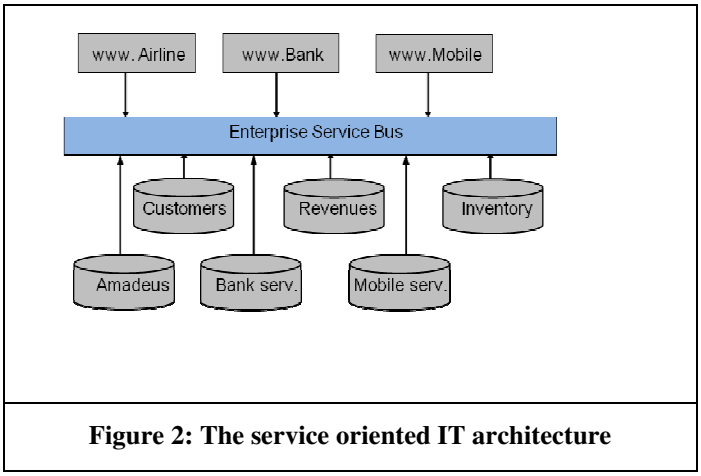

Figure 2: The service oriented IT architecture

Step 3: Theoretical re-description

The events were analyzed over time to generalize and abstract. It was found that they all fitted into a service innovation pattern; new Internet based services were a key business strategy of the company, and they all seemed to have a basis in the IT architecture. There also seemed to be a dynamic process at work; new services were innovated and made available, and the increasing number of elements seemed to provide a kind of resource for more innovation. Was there a recursive process?

This led to a re-conceptualization of the whole case. Instead of seeing it as the execution of a business strategy, it could be seen as the growth of a large information infrastructure (Ciborra and Failla 2000; Hanseth and Lyytinen 2010). The infrastructure is defined as the *installed base* of organizations, systems and users, i.e. the Norwegian Corp, its partners, the related IT systems and the Internet users of the solutions.

Theorizing further on this socio-technical object, the infrastructure could be seen as an *assemblage* (DeLanda 2006); a whole whose behavior cannot be explained by its components; it is emergent. This emergence can be described more precisely in terms of mechanisms, which produce the outcomes.

Step 4: Retroduction: Identification of candidate mechanisms

After step #3 the research question could be reformulated; which mechanisms can explain innovation and growth of information infrastructures?

Sub-step 4.1: The interplay of objects

The researcher started by trying to identify the external attributes of the key objects, i.e. the capacities to interact with other objects. The organizational structure of Norwegian was relatively flat, and the culture

of the company was entrepreneurial and open. This seemed to indicate that innovation could happen at several levels, and was not necessarily dependent on top management directives. Further, we noted that the IT department was small, and staffed with very experienced employees, most of them with a background from airlines and services. It was also noted that the (SOA) IT architecture was very flexible, allowing for the adding or subtraction of components at relative ease.

Looking for the interplay of the organization and the IT architecture, it was observed that some key actors were involved in most innovation events. They were key IT people with a strong knowledge of business issues, often acting as project managers. On the other hand, these projects were always business driven, not technology driven. These people were interviewed extensively; aiming to identify the arenas of interaction and the particularities of technical solutions.

Sub-step 4.2: Looking for macro-micro and micro-macro mechanisms

The researcher chose to regard the infrastructure as a *whole* (an assemblage); and to identify one or more mechanisms that worked recursively, i.e. were self-feeding, in the sense that innovation leads to more innovation. This structure should explain how the information infrastructure is generating innovation, and also how the innovations are modifying the information infrastructure.

Analyzing the interview transcripts, an expression that appeared frequently was that a *space of possibilities* was the starting point for innovation. What constitutes this space? One informant emphasized the business opportunity by logic of analogy; that a successful service (such as airline booking) is *similar* to the business of a mobile operator. Other informants pointed to the service oriented architecture, which allows for easy and flexible integration of new components. Yet another informant emphasized the role of external partners in idea generation.

Looking more explicitly for underlying mechanisms, these perspectives were synthesized into a more comprehensive structure, illustrated in figure 3. We found that the space of possibilities was enabled by a diverse, but structured, assemblage of technical and social components of the information infrastructure. This allowed key actors to experiment and combine existing and new components into new services. A very similar mechanism was identified (although at a business level, not service level) by Davenport and Short (1990). It is also a parallel to the *learning mechanism* in information infrastructures (Hanseth and Braa 2001).

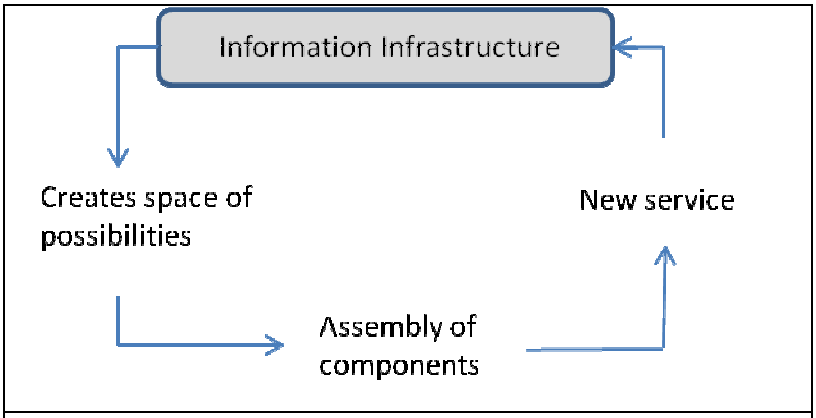

Figure 3. The Innovation Mechanism

The first part of this causal structure is the macro-micro mechanism. The second part illustrated with the upward arrow ("New service"), is the micro-macro mechanism. After the action on the micro level has generated a new service, it is integrated into the information infrastructure. This step may include contracts with vendors, technical testing and integration, and also training of personnel and marketing, and monitoring of customer responses.

The extended information infrastructure will, in this self-reinforcing structure, increase the space of possibilities. To get the full picture we must understand not only the innovation mechanism, but also how the infrastructure attracts more users. In the Norwegian case we observed that a growing infrastructure with a high volume of traffic also attracted more service providers, such as rental car companies, hotel chains and others. More services make the infrastructure more valuable for users, which attracts more users. We suggest to call this the *self-reinforcing adoption mechanism*, illustrated in figure 4. Its structure is rather similar to Grindley's (1995) standardization mechanism.

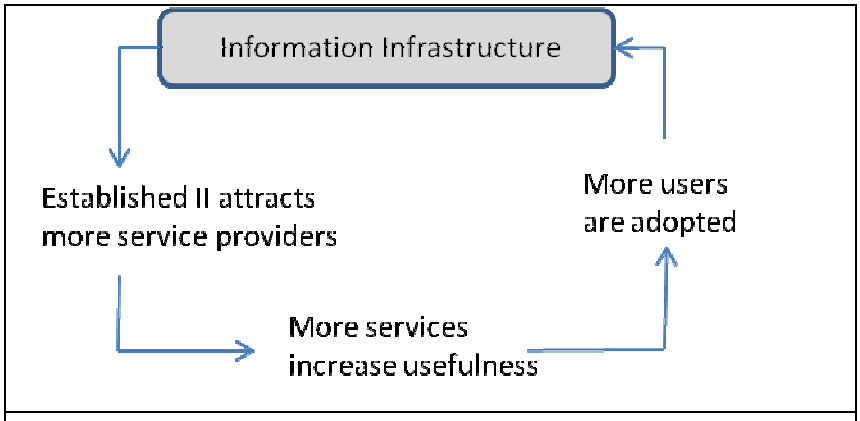

Figure 4. The self-reinforcing adoption mechanism

The two mechanisms feed on each other; the innovation mechanism generates more services, making the infrastructure more attractive, while the adoption mechanism generates more profits, enabling the development of more services.

Step 5: Analysis of selected mechanisms and outcomes

The format often used is Context – Mechanism – Outcome (Pawson and Tilley 1997). The context of the two mechanisms is information infrastructures, i.e. large inter-organizational IT-based structures, which provide services to a large number of customers via the Internet.

As illustrated in figures 3 and 4 the information infrastructure has two self-reinforcing mechanisms. First, there is the innovation reinforcement mechanism, which was described above. At the macro (infrastructure) level the result of the mechanism is a new service which extends the information infrastructure. Together, these two mechanisms explain two key aspects of information infrastructures; how they innovate and how they grow. A precondition for this mechanism to work – as described in the Norwegian case - is a flexible IT architecture that allows for relatively easy additions of components, and an organization that allows for innovation at different levels.

The second mechanism is the self-reinforcing adoption mechanism, which is built on Grindley's (1996) standard's model. The result of this mechanism is more users to the information infrastructure. A precondition for this mechanism to work is a degree of technological openness (in terms of standards) that allows the interplay with external service providers, and also the ability of the organization to engage in rapidly changing business networks.

Step 6: Validation of explanatory power

What makes a mechanism more plausible than another? The short answer is that we should choose the mechanisms that offer the strongest explanatory power in relation to the empirical evidence (Sayer 1992, 2000).

In the Norwegian case two other possible mechanisms were systematically evaluated against the empirical evidence. First, it was assessed whether the innovations could be explained with the *market mechanism*; that the external demand for services was matched with the internal capabilities to satisfy this at a competitive price. Certainly, this explanation cannot be dismissed, but it was not well supported by the empirical evidence. There were no systematic process at Norwegian to detect and respond to such demand, and the key innovators were relying much more on experimentation than on market analysis.

Alternatively, in a more Schumpeterian view one might hypothesize that the key mechanism was *entrepreneurial drive* of the charismatic CEO of Norwegian. Again, this could explain some of the observed outcomes, but not satisfactory. For example, it emerged through the study that although the CEO was very innovative in the airline industry, he was hardly interested in IT, and little involved in the actual innovation processes described here.

Thus, the result of this analysis was that although several mechanisms are at work, only the two mechanisms described above were consistent with the whole data material, including feedback from key informants.

The Mechanism Approach: Research Opportunities and Limitations

In this section we will discuss the opportunities and limitations of the mechanism approach. Overall, we argue that the mechanism approach has the potential to improve empirical studies in the IS field, by providing ontological depth and more precise explanations. We will also argue that the search for mechanisms spurs creative thinking.

In our example with the Norwegian company, a key question is whether the proposed mechanisms could have been identified using other research approaches, such as a positivist or interpretive approach? We believe that they actually could, but with much more difficulty. From a positivist perspective the analysis could have focused on, for instance, the links between events, in order to investigate whether the same type of event led to the same results, in order to identify a pattern. From an interpretive view, the hermeneutic principles discussed by Klein & Myers (1999) could be used to develop a shared understanding about, for example, how boundary-spanning communication and sense-making was necessary to innovate successfully. Thus, while possible it is not very likely that these approaches could have identified the two mechanisms as described, because the mechanism operates at the level of objects and structures, not at the level of observable events or perceived understanding.

Bearing this in mind we will argue that the main contribution of a critical realist analysis is ontological depth, creative thinking and precise explanations.

Ontological depth

Critical realist researchers argue that there is a necessary connection between ontology and methodology. As expressed by Margaret Archer, "an ontology without a methodology is deaf and dumb; a methodology without an ontology is blind" (Archer, 1995 p.28). It should be emphasized that critical realism is primarily an ontology, not an epistemology (Yeung 1997); it cannot tell us how to find the truth. Rather it accepts the interpretive epistemology, but insists that our object of study exists in a layered reality.

This layered ontology (illustrated in figure 1) is the methodological foundation of critical realism, focusing on the interplay of events, structures and mechanisms. In this paper we have tried to show how the ontological depth of critical realism offers the researcher an opportunity to go below the level of events and investigate the more stable structures and mechanisms.

Creative thinking

The theoretical re-description of the case allows for abstraction and creative thinking (Danermark et al. 2002). Self-reinforcing mechanisms are well known from earlier IS research (Davenport and Short 1990; Grindley 1995), and our example shows how the researcher may use his or her creative abilities to combine theoretical perspectives (such as information infrastructure and assemblage theory),

documented mechanisms and empirical evidence. Thus, we argue that the process of abduction and retroduction is basically a creative, but systematic process.

Precise and transparent explanations

Markus and Robey noted that "organizational change emerges from an unpredictable interaction between information technology and its human and organizational users" (Markus and Robey 1988, p. 585). While mechanisms cannot predict outcomes in a general sense, we suggest that they can explain these outcomes more detailed than other approaches.

A mechanism, such as the self-reinforcing innovation mechanisms in the Norwegian case, describes relatively precisely how innovation and growth actually takes place in information infrastructures, in the sense that they address the causal structure that produces an outcome. They describe in detailed steps how the outcome is produced; not only that there is an association between two phenomena. There are two important benefits stemming from this; first, it allows the researcher to establish a chain of causality, and to investigate such phenomena as self-reinforcement; second, it allows the reader to assess the documented evidence, in order to assess the credibility of the proposed mechanisms. This transparency is a key feature that allows the research community to engage in discussion and evaluation.

Limitations

Finally, there are certainly also limitations with the mechanism approach. Mechanisms are proposed to constitute the "nuts and bolts" of middle range theory (Elster 2007), but there is a delicate balance between too generic and too contingent mechanisms; if a mechanism is too general it loses explanatory power, if it is too specific it becomes relevant only in the single context where it was identified. In practice it is the experience and domain knowledge of the researcher that must guide him or her in conducting this balance. Does this mean that it is too pretentious, as Bunge (2004) contended, to speak about a method? The observation that the philosophical and theoretical critical realist contributions appear to be stronger than the methodological ones, has led some researchers to ask whether critical realism is "a philosophy in search of a method" (Yeung 1997).

Another objection may be raised from an interpretive perspective. The process of conjecturing and assessing mechanisms implies that the researcher has insight in the socio-technical structures that goes beyond the knowledge of his or her informants. From an interpretive view for example Giddens warned that the social scientist does not have a privileged access to knowledge that ordinary social actors do not have (Giddens 1984). As described by Sayer (1992), a proposed mechanism should be treated as a candidate explanation, and the data collection and analysis should be repeated until closure is reached. The process of "closure", however, is – again – largely dependent on the theoretical insights and domain knowledge of the researcher (Langley, 1999).

One might also ask, what is really new in this search for mechanisms? Some interpretive researchers have criticized critical realism for being a disguised positivist approach (Monod 2004), while in the opposite view critical realism has been suggested as a possible philosophical foundation for interpretive research (Walsham 2006), arguing that the search for mechanisms is congruent with the phenomenological aim of looking below the surface of events. We believe that both these positions are in conflict with the basic ideas of critical realism, but we agree that in the context of practical IS research these distinctions are less clear-cut than in philosophical treatises.

These limitations make it clear that the search for mechanisms is no easy recipe for the IS researcher; rather it is a challenging and creative task. A method cannot replace the need for domain knowledge and research experience. The approach has, however, in our view, the potential to provide a richer and more precise set of explanations in the field.

Conclusion

This article contributes to the research on critical realist methodology by presenting a stepwise framework for data analysis that may aid the researcher in identifying generative mechanisms. Exemplified through

the analysis of a longitudinal case study, we argue that this approach can have an important role in IS research in identifying causal structures of an ontological depth that is difficult to unveil through alternative approaches based on positivist or interpretivist perspectives. We also believe that the mechanism approach may have fruitful implications for IS practice.

However, we have also pointed out several challenges in this approach, and there is clearly a need for more research on critical realist methodology to detail the steps involved. In particular, further research could focus on developing heuristics for analyzing the interplay between mechanisms and reaching closure in the selection of the key mechanism(s) at work.

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